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An overview of the SeaWiFS project and strategies for producing a climate research quality global ocean bio-optical time series

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Abstract

The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project Office was formally initiated at the NASA Goddard Space Flight Center in 1990. Seven years later, the sensor was launched by Orbital Sciences Corporation under a data-buy contract to provide 5 years of science quality data for global ocean biogeochemistry research. To date, the SeaWiFS program has greatly exceeded the mission goals established over a decade ago in terms of data quality, data accessibility and usability, ocean community infrastructure development, cost efficiency, and community service. The SeaWiFS Project Office and its collaborators in the scientific community have made substantial contributions in the areas of satellite calibration, product validation, near-real time data access, field data collection, protocol development, in situ instrumentation technology, operational data system development, and desktop level-0 to level-3 processing software. One important aspect of the SeaWiFS program is the high level of science community cooperation and participation. This article summarizes the key activities and approaches the SeaWiFS Project Office pursued to define, achieve, and maintain the mission objectives. These achievements have enabled the user community to publish a large and growing volume of research such as those contributed to this special volume of Deep-Sea Research. Finally, some examples of major geophysical events (oceanic, atmospheric, and terrestrial) captured by SeaWiFS are presented to demonstrate the versatility of the sensor.
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1. Introduction

The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) was the result of a persistent effort by the ocean biogeochemical remote sensing community to have an operational ocean-color satellite following the great success of the experimental Nimbus-7 Coastal Zone Color Scanner (CZCS). Planning activities (Ocean-color Science Working Group, 1982; Joint EOSAT/NASA SeaWiFS Working Group, 1987) paralleled and supported the argument to include global ocean-color observations in the Earth Observing System (EOS; Asrar and Dozier, 1994; King et al., 1999) that ultimately resulted in the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua platforms. The strategy was to have SeaWiFS launch precede the MODIS launch by several years to initiate a global ocean-color time series in support of the Joint Global Ocean

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Flux Study (JGOFS) process studies in the Arabian Sea, equatorial Pacific, and Southern Ocean and to provide ample time to design and validate sensor calibration strategies and algorithms in preparation for the MODIS time series. In addition, SeaWiFS was to be the first in a series of US and international ocean-color missions that would eventually provide a long-term record of ocean biological and optical properties for climate research. In 1990, the NASA Goddard Space Flight Center (GSFC) initiated a competitive ocean-color data-buy procurement and established a SeaWiFS Project Office (SPO).

A data-buy contract with Orbital Sciences Corporation (OSC) was finalized in 1991 with an expected launch in mid-1993. NASA was to have insight, but not oversight, into the spacecraft and sensor design, construction, and testing. Under the contract, OSC was responsible for building, launching, and operating the spacecraft. Originally, the spacecraft was called SeaSTAR, but it was renamed after launch to OrbView-2 when Orbital Imaging Corporation (ORBIMAGE) purchased the spacecraft from OSC. The payment schedule was front-end loaded so that most of the fixed costs were paid at the completion of specific milestones during the prelaunch system development and postlaunch data acceptance phases. After acceptance, fixed monthly payments have been made, subject to penalties if the data quality is less than nominal (to date, no penalties have been applied). NASA's responsibilities included sensor and onboard recorder scheduling (sensor tilting, solar calibrations, lunar calibrations, internal sensor test sequences, and high-resolution data recording), postlaunch sensor calibration, derived product algorithm development, data acquisition [coarse resolution global area coverage (GAC) and fine-resolution local area coverage (LAC)], data processing, research data archival and distribution, and selection of high-resolution picture transmission (HRPT) stations. With these activities in mind, the SPO was organized at GSFC with a project manager, a project scientist, and project element leaders, the elements being Data Capture, Mission Operations (MO), Instrument Science, Calibration, Validation, and Data Processing (DP). Over time, the Instrument Science, Calibration, and Validation elements were merged to form the Calibration and Validation (CV) element.

The prelaunch phase was characterized by an unprecedented level of cooperation between NASA, OSC, and the instrument subcontractor, Hughes Santa Barbara Research Center, given that the contract did not require a high degree of interaction. In fact, GSFC engineering groups made many voluntary contributions towards resolving a number of technical problems with spacecraft components and subsystems, e.g., radiation hardness, power, navigation and attitude control, and telemetry. Throughout the prelaunch phase, OSC demonstrated a firm resolve to achieve success, even at considerable expense to the company. In addition, NASA Headquarters provided steadfast support to the SPO. Despite the best efforts of all parties, the launch schedule slipped 4 years. In August 1997, the prelaunch phase culminated in a flawless Pegasus-XL launch, and SeaWiFS has delivered a continuous stream of GAC and LAC data of unprecedented quality since September 1997.

The original science goals and project objectives, listed in Table 1 (Hooker et al., 1992), were defined to support quantitative research. The initial product suite was very similar to that of the CZCS and included total radiances (level 1 data), normalized water-leaving radiances, chlorophyll-*a*, diffuse attenuation (490 nm), and certain atmospheric correction-related parameters (level-2 products), and binned and standard mapped products at various temporal resolutions (level-3 products), e.g., daily, 8-day, and monthly (Darzi, 1998). The radiometric and chlorophyll-*a* accuracy goals are quite rigorous and have proved challenging to meet. Given the aggressive launch schedule, calibration and validation activities were to be coordinated with those of the MODIS Oceans Team that were already underway. The SPO also sought the science community's involvement in each aspect of the program to capitalize on their expertise, to explore new applications of the data, and to ensure the greatest possible utilization of the data for Earth system science. The SPO benefited greatly from its collaborations with the MODIS Oceans Team, the science community at large, and the Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) program (Fargion and McClain, 2002; McClain et al., 2002) which provided processing algorithms, in situ data sets, and much guidance.